

Traffic Engineering Tool Box



1. Crash Statistics Overview



2. Identification of Hazardous Locations



3. Traffic Engineering Tool Box



4. Lessons Learned



5. Traffic Safety Resources

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Road Safety Audits



For Existing Roadways

When: Make your safety audit a regularly scheduled on-going task.

Where: All classifications of streets and highways.

What: {Sample of suggested subjects}

Sight Lines & Distances

Roadside Hazards

Proper Delineation

Sufficient Warning Devices

Correct Traffic Control Devices

Correct Timing of Devices

Proper Lane Width & Turning Radius

Properly Installed Guide-rail etc.

Pavement Management

Who: People with experience in both design and maintenance of streets and highways.

For New Designs

The Stages of Design Auditing:

Stage 1: Feasibility Design

Stage 2: Preliminary Design

Stage 3: Detailed Design

Stage 4: During Construction

Stage 5: Pre – Opening

Stage 6: Post – Opening,
Existing Conditions

Roadside Safety Process



Roadside Safety Standards & Roadside Design

Roadside Safety Planning Fundamentals:

- Adopt Professional Roadside Standards
- Develop A Safety Audit System
- Remove Roadside Hazards Such As Trees
- Increase Setbacks For Utility Poles
- Flatten Ditch Slopes
- Make Safety a Design Priority
- Upgrade Roadside Hardware
- Protect the Fixed Object
- Provide advance Warning: Delineation or Sign
- Planning Tool-kit -AASHTO Roadside Design Guide-Prioritized Safety Audit Procedure

Quick Facts

Nationwide 2001:

- 12,692 people died in roadside fixed object crashes. This was an increase of 16% over 1975 and an increase of 3 percent over 2000.
- Roadside fixed object crashes accounted for 30% of all fatalities involving motor vehicles.
- The greatest percentage of roadside fixed object crashes involve collisions with trees.

2001 Michigan Crash Facts:

- There were 1,206 fatal crashes in Michigan in 2001.
- Of the 273 fatal roadside fixed object crashes in Michigan, 146 involved collisions with trees.
- The next highest fixed object involved in off road fatal crashes was utility poles with 27 fatal crashes.

Tangent Alignments vs. Curvilinear Alignments



Tangent Alignments vs. Curvilinear Alignments



NOT DRAWN
TO SCALE

5 Miles
Tangent Alignment

1.5 Miles
Curvilinear

Item:	Tangent	Diff.	Curvilinear
Length	5.0 mi.		1.5 mi.
Crash Freq.	4.6/mi.	+117%	10/mi.
Volume VPD	550	+36%	750
Crash Rate C/MVM	1.2	+67%	2.0
% Run off Road	65%	+43%	93%
% Night Crashes	43%	+23%	53%

HIGHLIGHTS:

- A number of safety research reports have concluded that curvilinear alignments are more hazardous than comparable segments of tangent roadway.
- A study recently completed in Blue Earth County of a 6.5 mile segment of County Hwy 20 documented the following differences in crash characteristics, as shown in the chart to the left.
- This information provided the support for the County's decision to include alignment improvements as part of their county highway reconstruction project.

Intersection Sight Distance

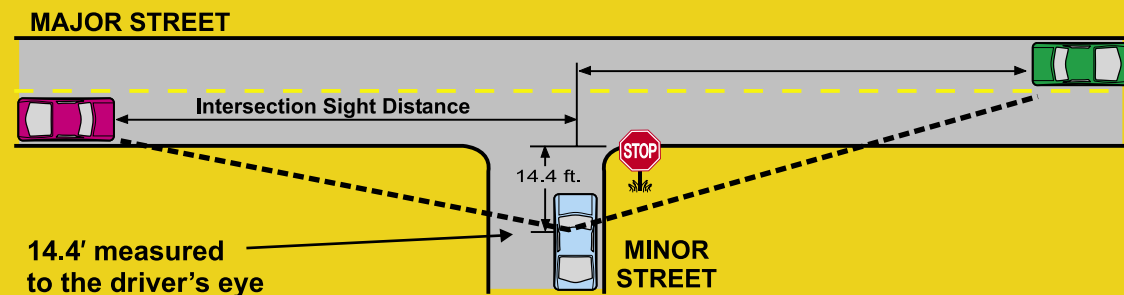


HIGHLIGHTS:

- Intersection sight distance (ISD) refers to the length of the gap along the major roadway sufficient to allow a cross street vehicle to either safely turn or cross.
- Each quadrant of an intersection should contain a triangular area free of obstructions that might block a stopped driver's view of approaching vehicles.
- Within a sight triangle, any object that would obstruct a driver's view should be removed or lowered, if practical. It is assumed that the eyes of the driver are 3.5 feet above the roadway. Such objects may include: buildings, parked vehicles, structures, vegetation, fences, and earth.
- If the minimum sight distance is provided then drivers will have sufficient time to avoid collisions.
- Sight distances that exceed the minimum are desired.

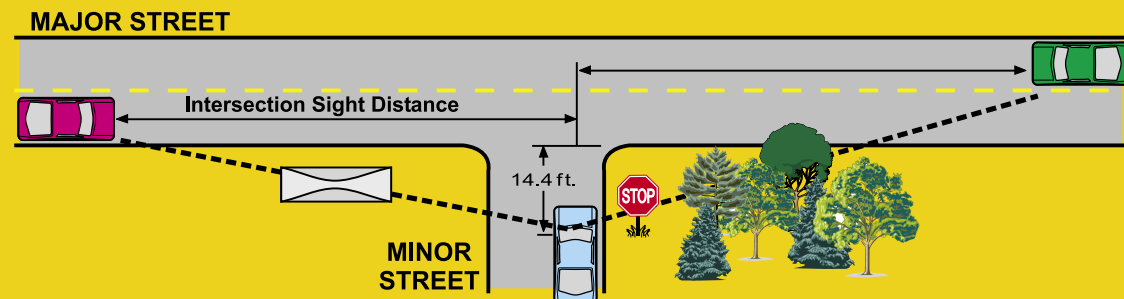
Adequate Sight Distance

Clear Sight Lines



Inadequate Sight Distance

View Obstructed by sign, vegetation, and bus shelter.



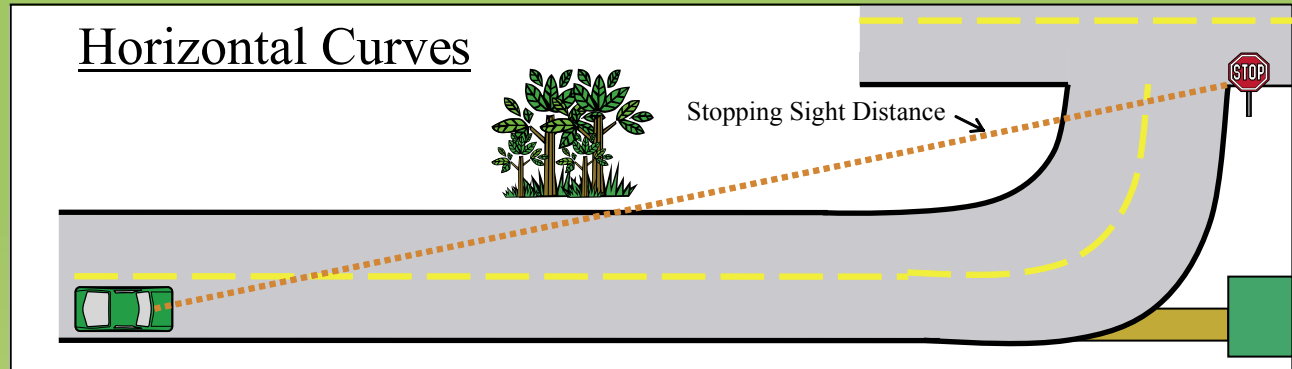
Stopping Sight Distance



HIGHLIGHTS:

- Stopping sight distance (SSD) refers to the length of the roadway ahead that is visible to the driver.
- The available sight distance on a roadway should be sufficiently long to enable a vehicle traveling at or near the design speed to stop before reaching a stationary object in its path.
- SSD on horizontal curves requires clear vision zones between the vehicle and the traffic control device that must be devoid of vegetation or structures
- SSD on vertical curves requires a “flat” area between the vehicle and the traffic control device.
- If the minimum SSD distance is provided then drivers will have sufficient time to brake.
- Sight distances that exceed the minimum are desired.

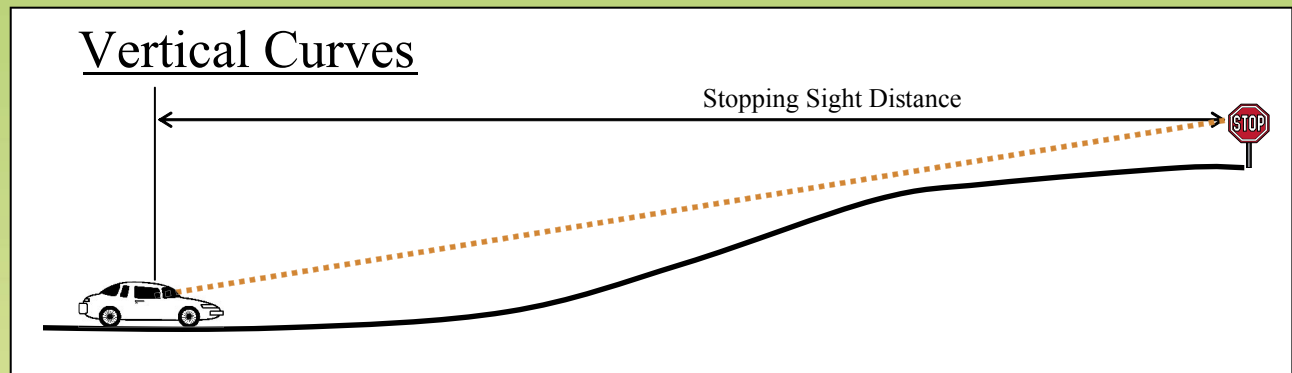
Horizontal Curves



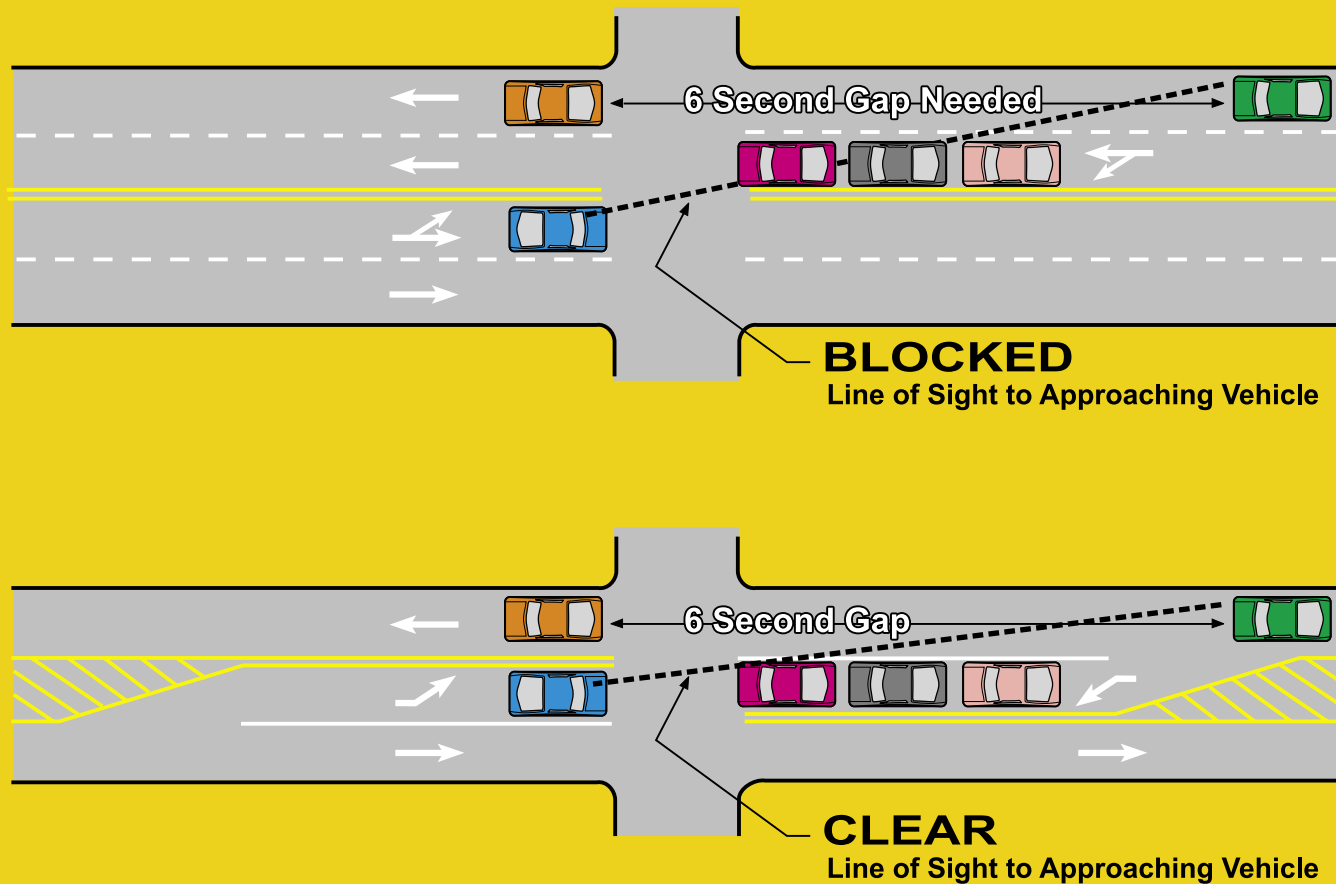
Roadway Design Speed (mph)	30	35	40	45	50	55	60	65
Minimum Stopping Sight Distance (feet)	200	250	305	360	425	495	570	645

NOTE: Design speed is typically 0-10 mph higher than posted speed. SSD increases on grades.

Vertical Curves



Effect of Left Turn Design on Sight Distance



Highlights:

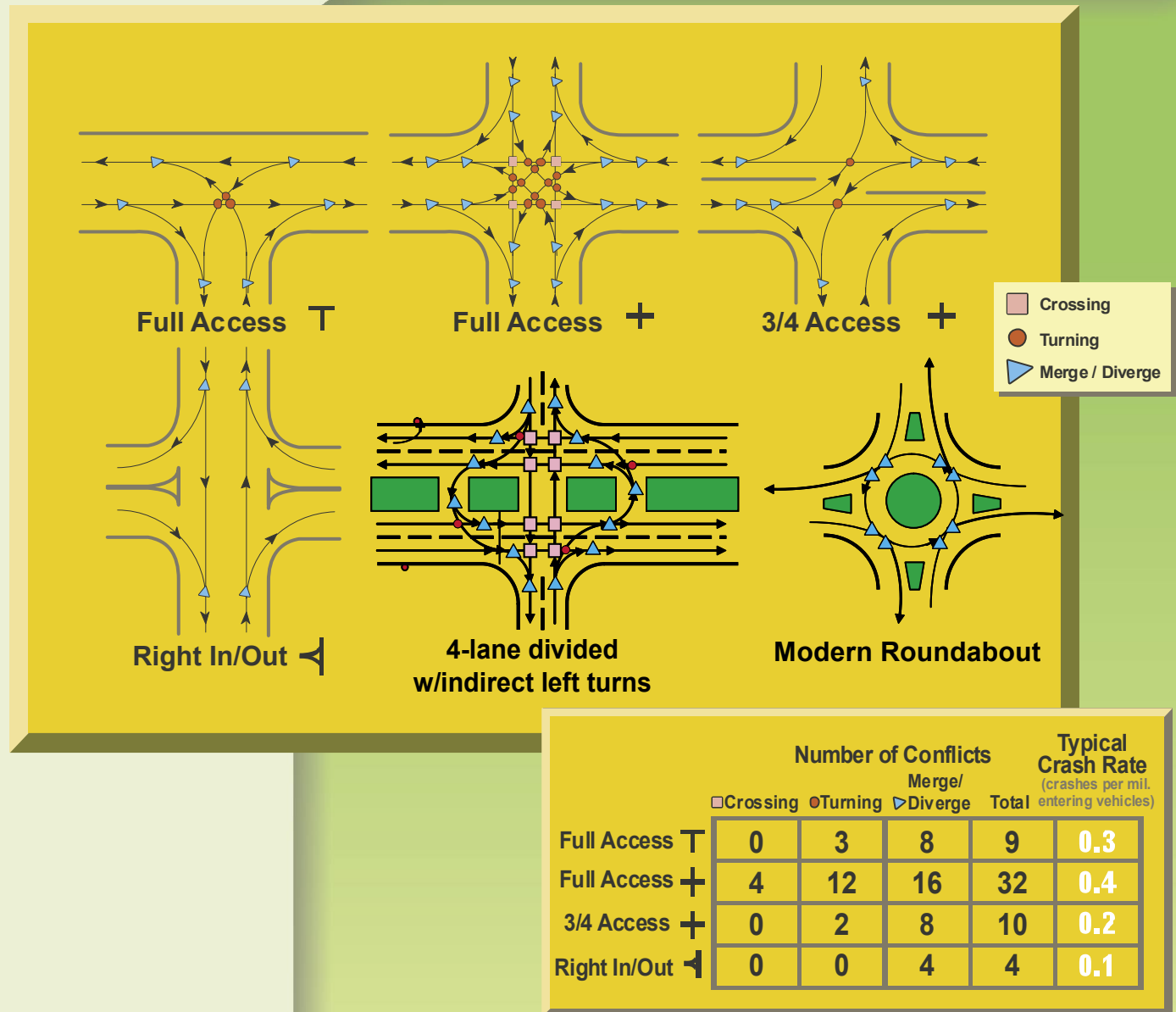
- The design of left turn lanes has a significant impact on both intersection operations and safety.
- Basically, if the opposing left turn lanes are offset, the line of sight to oncoming{conflicting} through traffic is intercepted by the queue of vehicles across the intersection. This type of design also encourages the opposing left turns to “lock up”, which adversely affects the intersection operations. These deficiencies help explain why left turn crashes are one of the most common types at urban intersections.
- If opposing left turn lanes are head-up, the line of sight to oncoming through traffic is not intercepted by the queue of vehicles across the intersection. As a result, drivers have better sight distance and an improved chance of selecting a safe gap.
- This head-up design is one of the reasons that converting 4-lane roads to either 3-lane or 5-lane roads usually results in improved safety.

Intersection Conflict Points: Full vs. Partial Access



Highlights:

- There is some information that suggests that intersection crash rates are related to the number of conflicts at the intersection.
- Conflict points are locations in or on the approaches to an intersection where vehicle paths merge, diverge, or cross.
- The actual number of conflicts at an intersection is a function of the number of approaching legs ("T" intersection have fewer conflicts than 4-legged intersections) and the allowed vehicle movements (intersections where left turns are prohibited/prevented have fewer conflicts than intersection where all movements are allowed).
- A preliminary review of intersection crash data indicates two key points:
 - Some vehicle movements appear to be more hazardous than others. The data indicates that minor street crossing movements and left turns onto the major street are the most hazardous (possibly because of the need to select a gap from two directions of on-coming traffic). Left turns from the major street are less hazardous than the minor street movements, and right turn movements are the least hazardous.
- Crash rates at "T" intersections are typically lower than at similar 4-legged intersections and prohibiting/preventing movements at an intersection will likely reduce the crash rate.



Typical Benefit/Cost Ratios for Various Improvements

(1974 – 1993)



RANK	CONSTRUCTION CLASSIFICATION	B/C RATIO
1	ILLUMINATION	21.0
2	RELOCATED BREAKAWAY UTILITY POLES	17.2
3	TRAFFIC SIGNS	16.3
4	UPGRADE MEDIAN BARRIER	13.7
5	NEW TRAFFIC SIGNAL	8.3
6	NEW MEDIAN BARRIER	8.3
7	REMOVE OBSTACLES	8.3
8	IMPACT ATTENUATORS	7.8
9	UPGRADE GUARDRAILS	7.6
10	UPGRADE TRAFFIC SIGNALS	7.4
11	UPGRADE BRIDGE RAIL	7.1
12	SIGHT DISTANCE IMPROVEMENTS	7.0
13	GROOVE PAVEMENT FOR SKID RESISTANCE	5.6
14	REPLACE OR IMPROVE MINOR STRUCTURE	5.2
15	TURNING LANES AND TRAFFIC SEPARATION	4.4
16	NEW RR FLASHING GATES	3.9
17	CONSTRUCT MEDIAN FOR TRAFFIC SEPARATION	3.3
18	NEW RR CROSSING FLASHING LIGHTS	3.2
19	NEW RR FLASHING LIGHTS AND GATES	3.0
20	UPGRADE RR FLASHING LIGHTS	2.9
21	PAVEMENT MARKING AND DELINEATION	2.6
22	FLATTEN SIDE SLOPES	2.5
23	NEW BRIDGE	2.2
24	WIDEN OR IMPROVE SHOULDER	2.1
25	WIDEN OR MODIFY BRIDGE	2.0
26	RE-ALIGN ROADWAY	2.0
27	OVERLAY FOR SKID TREATMENT	1.9

Highlights:

- These benefits/costs should only be used as a guide and not as the definitive expected value at any particular location. Specific solutions and their potential benefits require detailed analysis, planning and evaluation.
- MDOT funded safety research has documented benefits/costs for the addition of exclusive turning bays which yielded B/C ratios of 3.0, and installing medians for indirect left turns which yielded B/C ratios of 7.0. These are similar to the B/C ratios listed by FHWA.

Average Crash Costs



The 2002 economic loss in Michigan traffic crashes amounted to \$9.6 billion



That's over \$26 Million each day



That's an average cost of \$24,000 per crash



A 1% drop in annual crashes amounts to a \$94.8 million dollar savings

Notes:

- Economic loss typically includes lost wages, medical costs, property damage, legal and insurance costs
- This does not take into account the social and behavioral impacts crashes have

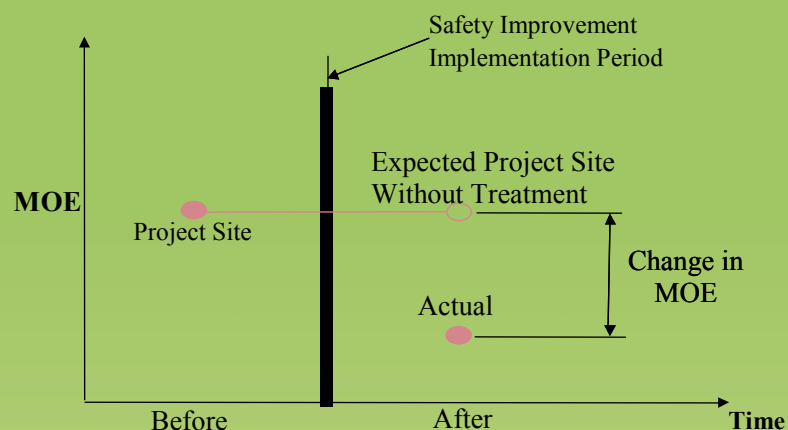
Enforcement Strategies



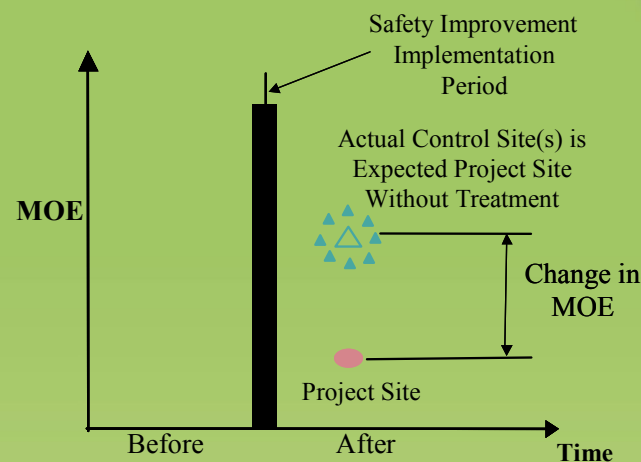
- Maintain and analyze crash data
- Verify & utilize information from citizens
- Saturation



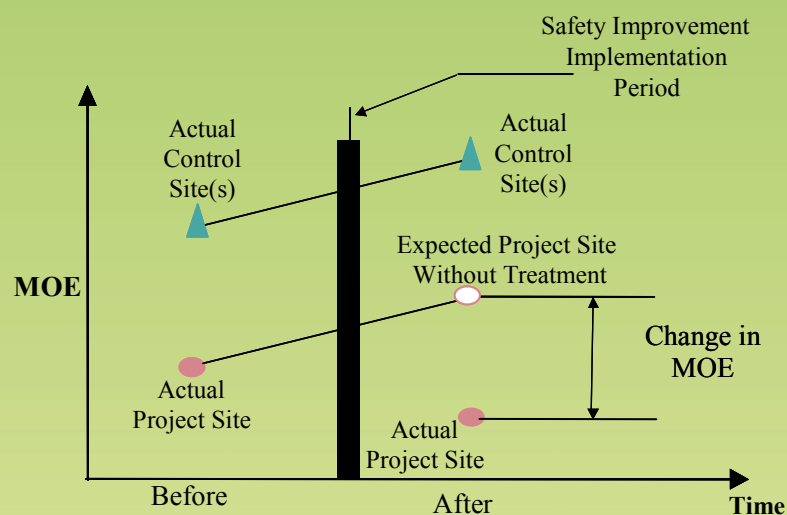
Evaluation Procedures



Before and After Study



Comparative Parallel Study



Before and After with Control Study

Highlights:

- Evaluations of safety treatments are conducted through a series of experimental plans including 'before/after' studies, 'Comparative parallel' studies and 'Before/after with control site' studies. The change in the measures of effectiveness (MOE) are then subjected to a series of statistical tests
- The difference between these 3 studies lie in the estimate of the MOE in the 'after' period had the treatment NOT been implemented
- The experimental plans are based on the assumption that the number of traffic crashes used in the analysis accurately reflects the number of crashes for the entire before or after analysis period. According to the Highway Safety Evaluation Procedural Guide and the Highway Safety Improvement Program Manual, both published by FHWA, a three year 'before' period and a three-year 'after' period should be selected for project evaluation. The three-year duration provides sufficient approximation to the long term average for a safety analysis. However, no significant change in geometric, traffic operations or traffic control conditions at the site should have occurred, except for the implemented countermeasure. It is also desirable to evaluate the effectiveness of the countermeasures as soon as possible in order to monitor how they are performing.

What is a Traffic Signal?



Any power operated traffic control device by which traffic is warned or directed to take some specific action

Advantages

1. Orderly movement of traffic
2. Increase traffic capacity
3. Reduced frequency of certain types of crashes
4. Provide for continuous movement of traffic
5. Interrupt heavy traffic to permit other vehicular or pedestrian traffic to cross

Disadvantages

1. Excessive/Unnecessary delay(s) may be caused
2. Disobedience of signal indications is encouraged
3. The use of less adequate routes may be induced in an attempt by the driver to avoid such signals

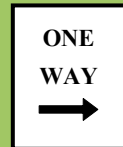
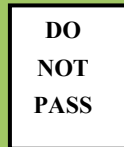
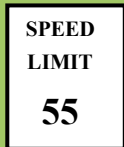
When to install a traffic signal

A traffic engineering study called a “warrant study” should be conducted to determine whether a traffic signal will improve the overall safety and operation of an intersection.

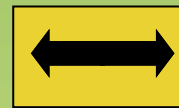
Highway Signs



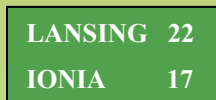
Regulatory



Warning



Guide



Other

Include signs for recreation areas, civil defense, etc.

Highlights:

- Sign categories include:
 - Regulatory
 - Warning
 - Guide
 - Other
- Regulatory signs inform drivers of traffic laws or regulations.
- Regulatory signs should be placed whenever needed to adequately inform drivers but not be overdone.
- Warning signs are used to warn drivers of conditions that may require increased awareness or caution.
- Warning signs may call for a reduction in speed or for a maneuver to be required.
- Warning signs are generally diamond shaped with a black legend and border on a yellow background.
- Guide signs provide drivers with information and directions to make it easier to find their way.
- Freeway Guide signs generally have a green background with white letters and/or numbers.

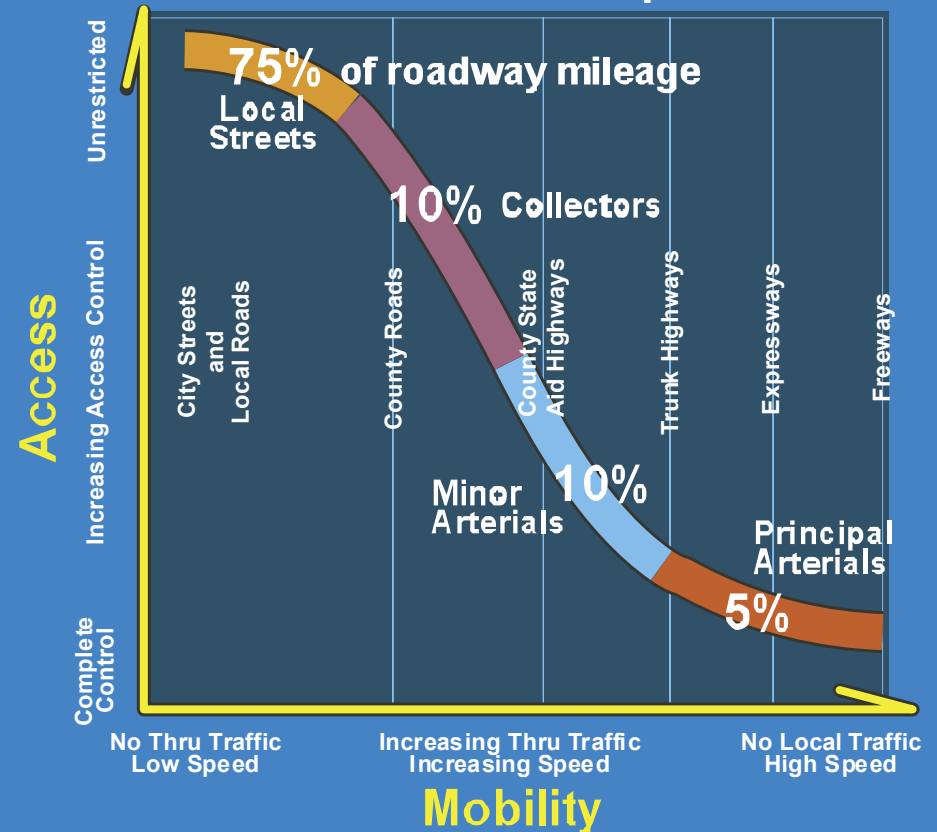
Access vs. Mobility



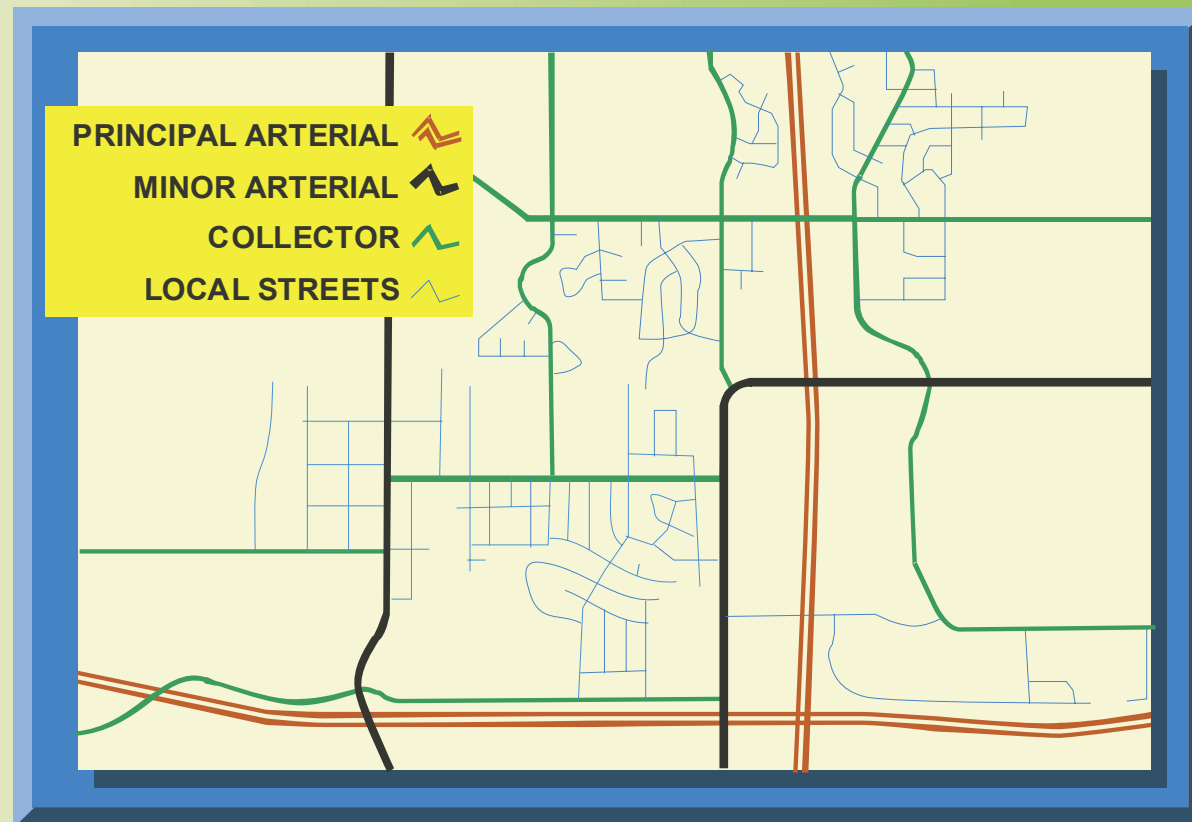
Highlights:

- One of the key concepts in transportation planning deals with the functional classification of a road system. The basic premise is that there are two primary roadway functions, access and mobility, and that all roadways serve one function or the other, or in some cases both functions.
- The four components of most functionally classified systems include: local streets, collectors, minor arterials, principal arterials.
- The primary function of local streets is land access and the primary function of principal arterials is moving traffic. Collectors and minor arterials are usually required to serve some combination of both access and mobility functions.
- Key reasons supporting the concept of a functionally classified system include:
 - It is generally agreed that systems that include the appropriate balance of the four types of roadways provide the greatest degree of safety and efficiency.
 - It takes a combination of various types of roadways to meet the needs of the various land uses found in most urban areas around the state.
 - Most agencies couldn't afford a system made up entirely of principal arterials and a region could be gridlocked if it was only served by a system of local streets.
 - Roadways that only serve one function are generally safer and tend to operate more efficiently. For example, freeways only serve the mobility function and as a group have the lowest crash rates and the highest level of operational efficiency.
- Functional classification can be used to help prioritize roadway improvements.
- The design features and level of access for specific roadways should be matched to the individual roadways intended function.
- The appropriate balance point between the competing functions must be determined for each roadway based on an analysis of specific operational, safety, design and land requirements.

Access vs. Mobility The Functional Class Concept



Typical Functionally Classified Urban System



Typical Characteristics

• Local Streets

Low volumes (less than 2000 VPD)
 Low speeds (30 MPH)
 Short trips (less than one mile)
 2-lanes
 Frequent driveways & intersections
 Unlimited access
 75% system mileage / 15% of VMT
 Jurisdiction - Cities & Townships
 Construction cost: \$250k / mile

• Collectors

Lower volumes (1000 to 7,500 VPD)
 Lower speeds (30 or 35 MPH)
 Shorter trips (1 to 2 miles)
 2 or 3 lanes
 Freq. driveways
 Intersections to 1/8th mile spacing
 10% system mileage / 10% VMT
 Jurisdiction - Cities & Counties
 Const. cost: \$ 500k to 750k / mile

• Minor Arterials

Moderate volumes (5k to 40k VPD)
 Moderate speeds (35 to 45 MPH)
 Medium length trips (2 to 6 miles)
 3 or 5 lanes
 Only major driveways
 Intersections at 1/4 mile spacing
 10% system mileage / 25% VMT
 Jurisdiction - Counties & State
 Const. cost: \$1.5M to \$2.5M / mile

• Principal Arterials

High volumes (20k to 250k VPD)
 High speeds (45 to 70 MPH)
 Longer trips (more than 6 miles)
 4 or 5 lanes or more - access control
 Intersections at 1/2 mile spacing &
 Interchanges 1+ mile spacing
 5% system mileage / 50% VMT
 Jurisdiction - State
 Const. cost: \$5M to \$50M / mile.